IN THE SPECIFICATION:

METHOD AND DEVICE FOR CONNECTION AND ADJUSTMENT OF OPTICAL UNITS: ELEMENTS, MODULES, DEVICES, AND SYSTEMS

~~Field of the Invention~~

~~The present invention relates to a method and a device for connection and adjustment of optical units (OA); elements, modules, devices and systems, in particular passive and/or active OA, aimed at controllable optimization of visual signals translation between the articles. The method and the device find application in optoelectronics, optomechanics, optical communications, instrument engineering, medical engineering, laboratory equipment, and all fields of technology using translation of visual signals between OU.~~

~~Prior Art~~

~~There is a device known for connection and adjustment of passive OU - optical fibers [1]. It is used to realize a method for the same purpose, according to which OU are arranged in pairs and fixed, one opposite the other in a frontal contact, to the respective carriers, one of the latter being movable. The two carriers with the OU are connected in a hermetically isolated from the environment optical channel with a guaranteed parallelism of the optical axes of the OU being optically connected through the channel. After that, the OU carriers are oriented in the space until the two OU get coaxial, i.e. until the necessary optimal translation of visual signals is achieved. Orientation is carried out by repeated iterative series of independent rectilinear stepwise shifts of the movable carrier in two inter-perpendicular planes, the latter being perpendicular to the axis of the carrier. Along with the carriers'~~

~~orientation, the movable carrier is frontally tightened and locked to the immovable one, each following shift increasing the locking force. Meanwhile, running check is carried out with respect to the orientation precision and the degree of the optical channel mechanical links sealing.~~

~~The device consists of two rigid OU carriers; a rigid body, i.e. a hollow nut, axially connecting and embracing the carriers; a soft flexible ring, disposed between the faces of one of the carriers and the nut, pressing them one to the other and sealing the optical channel, the latter being formed by the three rigid bodies; two adjusting screws and a spring support, used for the rectilinear displacement and locking of the movable carrier.~~

~~A common shortcoming of the method and device realizing it is that they allow only parallelism and coaxiality adjustment of the carriers, respectively of the OU optical axes.~~

~~A drawback of the method is the fact that its use is possible only upon preliminary and precise OU orientation for achieving guaranteed parallelism of their optical axes prior to fixing them to the carriers. This necessitates the use of complicated and expensive technology for the manufacture of the devices for the realization of the method.~~

~~A drawback of the device is the fact that its operational possibilities and reliability are limited, especially in cases of high temperatures and aggressiveness of the environment. Limitations are caused by the soft flexible ring having unstable mechanical characteristics, as well as by the mechanical links in the device construction, which are not resistant to vibration and shaking.~~

~~There is a device known for OU connection and adjustment, i.e. a reflecting optical element (concave mirror) and an active optical element contained in a sealed optical channel [2]. It is used to realize a method, according to which the reflecting element is fixed to a movable carrier opposite to the optical axis of an immovable carrier, the active optical element being fixed to the latter, while both OU carriers are connected in a sealed optical channel with a guaranteed precision of intersection of the optical axes of the OU carried thereby. Then, the OU get inter-oriented in space, the movable carrier moving towards the immovable axis of the active optical element of the immovable carrier by means of iterative stepwise spatial angular shifts around the point of intersection of the two OU optical axes, with a permanent force of pressure of the carriers' contact surfaces. Along with the iterative angular shifts of the movable carrier, a running check is carried out of the precision of the carriers orientation, the shifts being carried out until the required optimal interposition is achieved of the optical axes of the OU carried thereby.~~

~~The device consists of rigid bodies only, i.e. two OU carriers and a third one that embraces and connects the carriers, the three bodies being connected so that they form a sealed optical channel. Auxiliary rigid and springy mechanical elements ensure the axial inter-pressure of the bodies, while for the iterative spatial and angular shifts of the movable carrier there are adjusting screws provided for.~~

~~A common drawback of the method and the device is their restricted applicability. They can be used only for reflecting OU and for spatial and angular OU adjustment, for there are no ways and means provided for the connection and displacement of other OU, e.g. elements, modules, devices and systems, into directions perpendicular to the optical axis.~~

~~A shortcoming of the method is the fact that its realization necessitates the use of devices with a high technological precision of manufacture and assembly, such devices being able to guarantee preliminary technological precision of the OU optical ax intersection prior to their connection and following orientation.~~

~~A drawback of the device is its low operational reliability owing to the fact that its complicated construction is not resistant to vibrations and shocks.~~

~~Another drawback of the device is its narrow range of OU spatial adjustment owing to the small stroke of the adjusting screws used to effect the adjustment.~~

~~A device is known for OU connection and adjustment, i.e. fibers [3]. It is used to realize a method, according to which OU are arranged in pairs and fastened movably or immovably, at a distance one from the other, to the respective carriers, at least one of the latter being movable. Then, the two carriers with the OU fastened thereto are connected through a third, interstitial body, so that the three bodies form an optical channel isolated from the environment or communicating therewith, through which the carried OU get optically interconnected. The optical medium in the channel is homogeneous or heterogeneous as regards its composition and properties. The bodies forming the optical channel and carrying a certain pair of OU are angularly oriented in the space until the relative position is achieved necessary for the optimal translation of visual signals, i.e. the position of coaxiality, or parallelism, or intersection, or crossing of the optical axes of the OU carried thereby. The bodies are oriented by means of interdependent repeated, iterative series of rectilinear stepwise shifts and locking of the movable OU carrier or carriers (where both carriers are movable). The shifts and locking are accompanied by a running check of the relative position of the OU optical axes. Each angular displacement of~~

~~a body is preceded by a partial release from the locking, and is followed by a new, stronger locking and a check of the relative position of the bodies, respectively of the OU optical axes, for each partial release and new locking change, to a certain extent, the relative position of the OU carriers established so far. The iterative angular shifts of a movable OU carrier are carried out around a center of rotation, with variable space coordinates, towards the position of the same movable body.~~

~~Where the optical channel shaped by the three bodies, i.e. the two OU carriers and the interstitial body, has to be isolated from the environment, the last operation, i.e. the angular shift and the respective locking of the movable body, is followed by a final check as to whether the mechanical links between the bodies shaping the channel are sealed.~~

~~The device used to realize the method for OU connection and adjustment comprises at least three bodies, i.e. two end bodies and an interstitial one, for each adjusted OU pair. The bodies are connected and locked by means of screws, thus forming an optical channel with a homogeneous or heterogeneous medium, the channel being isolated from the environment or communicating therewith. At least two bodies of each triad have opposite central through holes shaping the opening of the optical channel, the axis of the latter being rectilinear in the case of one triad, or angularly refracted or branched from a common point in the case of more than one triad of bodies with an immovable end body common for all triads. Each of the two end bodies of each triad has a bearing surface, either smooth or threaded, for the respective OU to be secured thereto. One of those bodies, which is immovable, represents a housing of the device having an attachment surface for external mounting of the device to a panel wall or to a part of an apparatus. The two OU~~

~~secured to the carriers get locked, upon their optical communication, to the bodies at a certain distance one from the other, while their axes are angularly inter-oriented as a result of the shifts and locking of the carriers. These bodies are frontally or radially connected by the interstitial body, made of soft flexible material, by means of two kinds of screws, i.e. coupling/adjusting screws and locking screws. The screws are placed within the immovable carrier, respectively axially or transversally and radially to its axis, and are subjected to tension or compression. When orienting the OU carrier, the center of its angular displacement changes its position towards the body depending on the variable deformation of the interstitial body, caused by its screw tightening when displaced or locked. That center is disposed within the volume of one of the carriers or between the two end carriers or outside them, depending on the different embodiments of the invention. In the embodiments with an optical channel communicating with the surrounding, there is a transversal hole in the housing of the device for the channel communication.~~

~~A basic drawback of the method and the device realizing it is the fact that they allow a restricted spatial orientation of the carriers, i.e. only by means of angular shifts of the movable carrier/s. The method and device application is thus limited to cases of OU connection and adjustment for the purpose of optical beams communication and reflection in small angular ranges.~~

~~Still another shortcoming of the method and the device is the fact that the adjustment operational indexes achieved thereby are rather unsatisfactory, i.e.:~~

- ~~low precision due to the restricted or just angular displacement of the movable body/s and the geometrical scattering of the deviations when positioning~~

~~that body/s, caused by the variable position of the angular displacement center depending on the interstitial body deformation;~~

~~• low productivity caused by the great number of adjustment operations necessitated by the inconstant position of the angular displacement center of the movable body/s, as well as by the time separated operations for displacement and locking of the body/s.~~

~~A main drawback of the device is the fact that it has restricted functional possibilities, for it is fit for connection and adjustment of optical and optoelectronic elements only (fibers, reflectors), small angles being enough for the adjustment thereof, due to the limited spatial orientation of its carriers and the restricted possibilities for external mounting, i.e. by means of the end carrier only, for the interstitial one is flexible. The device is not fit for adjustment of optical articles whose optical axes require substantial angular deflections, for they use dispersing and double beam refracting optical elements, such as prisms, diffraction gratings, Wollaston prisms, etc.~~

~~Still another drawback of the device is the fact that it has low performance indexes:~~

~~• narrow adjustment range owing to the soft flexible interstitial body, which gets deformed when tightened by screws and necessitates a small displacement stroke of the movable carrier;~~

~~• low precision of positioning of the movable carrier due to the soft flexible link between the carriers, which destabilizes the angular displacement center of the movable carrier and causes considerable dispersion of the movable carrier positioning deviation;~~

~~• low adjustment productivity due to the great number of time-consuming adjustment operations necessitated by the soft flexible link between the carriers, as well as by the use of two kinds of screws, i.e. coupling and adjusting screws and locking screws, which are necessary for the time-separated displacement and locking effected by identical iterative operations, the latter being accompanied by partial loosening of the movable carrier/s;~~

~~• low reliability, especially in the case of high temperature, moisture, shocks, vibrations, which necessitate more strict requirements as regards the optical channel sealing, said low reliability being caused by the soft flexible interstitial body having unstable mechanical characteristics, respectively changing in the course of time flexibility of the link between the bodies shaping the channel.~~

~~There are no method and device for OU connection and adjustment, able to ensure: reliable mechanical connection of bodies carrying a wider range of OU, i.e. elements, modules, devices and systems; separate or combined optical communication, switching, branching, reflection, and damping of their directed or controlled optical beams, as well as efficient, i.e. wide-range, precise, highly productive spatial orientation of the connected OU for the purpose of achieving the required relative position thereof.~~

~~Technical Substance of the Invention~~

~~The method for OU connection and adjustment under the present invention consists in the following:~~

~~First, the OU to be connected and adjusted are arranged in pairs and fastened, either movably or immovably and at a distance one from the other, to carriers, at least one of the latter being movable. Then, the two carriers with the OU~~

~~fastened thereto are connected with each other by an interstitial body so that the three bodies form an optical channel isolated from the environment or communicating therewith, the OU getting optically interconnected through the channel. The optical medium in the channel is either homogeneous or heterogeneous as regards its composition and properties. The bodies forming the optical channel and carrying a certain OU pair are spatially oriented, until the relative position necessary for the optimal translation of optical signals is achieved, i.e. position of coaxiality, parallelism, intersection or crossing of the optical axes of the OU carried thereby. Orientation of the bodies is carried out by repeated or iterative sequences of stepwise shifts and locking of the movable carrier or carriers with the OU (where the movable carriers are two), accompanied by a running check of the relative position of the OU optical axes.~~

~~Besides, the iterative shifts of the carriers aimed at the spatial inter-orientation thereof are rectilinear and angular or angular and rectilinear. In the case of one movable and one immovable carrier, the orientation thereof is carried out by a series of iterative pairs of interdependent, consecutively alternating in each pair, rectilinear and angular, or angular and rectilinear shifts of the movable carrier, whereat the relative position of the OU axes, achieved by any rectilinear or angular shift of the body, gets partially changed by the next angular or rectilinear shift of the body. In the case of two movable carriers, the inter-orientation thereof is carried out by two consecutive series of mutually independent iterative shifts of each body, one of the series consisting of only rectilinear shifts of one of the bodies, while the second series consists of only angular shifts of the other body. In both cases the rectilinear shifts of the movable carrier/s are performed perpendicularly to the axis of~~

~~at least the interstitial body, the latter being movable or immovable (where the interstitial body and one of the carriers are coaxial, the shifts are perpendicular to the axis of the latter as well), while the angular shifts are effected around a permanent point on the axis of the angularly shifted carrier. In both cases, locking of each movable carrier is carried out along with the respective shifts or only during each angular shift following a rectilinear shift of the body. Besides, in each following operation the locking force gets stronger until its optimal value is reached in the last locking. Where the optical channel formed by the three bodies, i.e. the two carriers and the interstitial body, has to be isolated from the environment, the last operation, i.e. shift and respective locking of the movable body, is followed by a final check of the sealing of the mechanical links between the bodies forming the channel.~~

~~In order to effect the rectilinear shifts of the movable carrier (both in the cases of one or two movable bodies), the latter is acted upon along axes in a plane perpendicular to the axis of at least the interstitial body, either movable or immovable, while for performing of its angular shifts the movable carrier is acted upon along axes parallel to its axis or to the axis of the interstitial body.~~

~~According to the invention, the device for realizing the method of OU connection and adjustment comprises at least one triad of two end OU carriers and one interstitial body for each pair of OU being connected and adjusted. The bodies are connected and locked by screws, thus shaping an optical channel isolated from the environment or communicating therewith. At least two bodies of each triad have opposite central through holes that shape the opening of the optical channel, the latter having optical medium which is homogeneous or heterogeneous as regards its composition and properties. The optical channel axis is rectilinear in the case of one~~

~~triad of bodies, or angularly refracted or branched from a common point in the case of more than one triad of bodies having an immovable body common for all triads. The two end bodies of each triad have a bearing surface for the respective OU to be fastened thereto, and one of the three bodies is immovable and represents the housing of the device having a contact surface for external mounting of the device to the wall of a panel, apparatus, etc.~~

~~Besides, the three bodies of each triad are rigid, one of the end bodies and the interstitial body being axially connected through a spatial or plain hinge, while the second end body and the interstitial one are frontally connected in a common slip plane transverse to the axes thereof. The hinge contact surfaces represent either a part of a concave sphere and a right circular cylinder base, or a part of a concave cylindrical surface and a parallelepiped or a cube base, or a part of a concave ellipsoid and an elliptic cylinder base. Each of the concave contact surfaces of the hinge has either a center on the symmetry axis of the body hinged therein, or a central axis crossing the said symmetry axis. The center and the central axis of the respective concave contact surfaces of the hinge are disposed either between the bodies hinged therein, or within the volume of one of the end bodies, or outside the three bodies. The interstitial body and the second end body, frontally connected in the said slip plane, have each a front contact surface transverse to the axes thereof. The screws for connection of the bodies are locking at the same time, where the connected bodies are movable, i.e. shifting when effecting the adjustment of the OU carried thereby. The coupling and locking screws, some of which can be replaced by functionally equivalent bearing spring elements, are placed within one or two of the triads of bodies arranged in two groups according to the purpose they are~~

~~intended for, i.e. for effecting rectilinear or angular adjustment shifts of the movable body. A group of the screws are subjected to compression and are disposed along axes perpendicular to the interstitial body axis, as well as to the axis of the end carrier frontally connected therewith. The other group of screws are either subjected to compression and disposed along axes parallel to the axis of the carrier they are placed in, the carrier being hinged to the interstitial body, or subjected to tension and disposed along axes parallel to the axis of the body they are placed in and to the interstitial body as well. The two groups may comprise the same or different number of screws. The axes of the two groups of coupling and locking screws are intercrossing and/or perpendicularly intersecting.~~

~~Where the interstitial body represents the housing of the device, in addition to the contact surface for external mounting of the device it has also a bearing surface for an additional OA, which is disposed either between the two OU being interconnected and adjusted, or outside them.~~

~~The interstitial body may consist of axially connected movable and one immovable parts, the immovable part representing the device housing.~~

~~The contact surface for external mounting of the device represents a plane or a rotational surface of the respective immovable end or interstitial body representing the housing of the device.~~

~~According to an embodiment of the device, the transversally slipping interstitial body touches laterally a spring element/s disposed opposite coupling and locking screws, the latter being carried by the end OU carrier contacting with the interstitial body in a slip plane.~~

~~In some of the embodiments of the device, the contact surfaces of the hinged bodies and the contact planes of the bodies frontally connected in a slip plane are tightened by the coupling and locking screws for angular shifts of the movable body/s. In other embodiments of the device, it is only the contact surfaces of the hinged bodies that are tightened by the said screws, while the contact surfaces of the frontally slipped bodies are tightened into a constant, close fit in guides.~~

~~In all embodiments of the device, the coupling and locking screws for angular shifts of the movable carrier/s are placed along the axis of the optical channel of the device. In some of the device embodiments, the screws tighten together the three bodies of each triad. In other embodiments thereof, the same screws tighten the three bodies into pairs, the latter having a common body, i.e. the interstitial one, and an end carrier each.~~

~~The advantages of the method and the device for OU connection and adjustment, according to the invention, consist in the following:~~

~~1. The combination of operations according to the method, as well as the technological order and requirements concerning the execution thereof, allow to perform a wide-range, overall spatial adjustment of the relative position of the optically connected OA, as well as to make a universal device for separate or combined optical connection, switching, branching, reflection, attenuation of directed or controlled optical beams in an optical channel, the latter being isolated from or communicating with the environment. The method and the device realizing it ensure fine, repeated or iterative, spatial, combined, i.e. angular and transversal rectilinear orientation of coaxiality, or parallelism, or intersection, or crossing of the axes of the oppositely fastened OA, with a random initial position of the carriers in the space.~~

~~2. The method and the device ensure efficient adjustment of the optically connected OU with high operational indexes, such as:~~

~~• high precision, including in the case of a wide range of shifts of the movable body/s, owing to the combined spatial orientation thereof by angular and transversal rectilinear shifts, instead of only angular or only transversal rectilinear ones, as well as to the reduced geometrical scattering of the positioning deviations upon each angular shift around a center or an axis with constant coordinates on the axis of the angularly shifted carrier.~~

~~• flexible choice of the kind of adjustment, i.e. either combined, meaning angular and rectilinear, or separate, meaning only angular or only rectilinear.~~

~~• high productivity owing to the reduced number of adjustment operations, this being possible thanks to the permanent position of the center or the axis of the angular shift; owing also to the time coincidence of the movable body shift and locking operations; and owing also to the use of the interdependent iterative pairs of shift and locking operations in the case of one movable OU carrier.~~

~~3. The device has a universal construction permitting an overall and precise spatial combined orientation by means of an angular and a rectilinear transversal displacement of one of the movable end OU carriers or of the two movable end OU carriers, as well as the locking thereof. The construction ensures also universal mounting of different kinds of OA, i.e. elements (passive or active), modules, devices and systems, as well as external mounting, the rigid interstitial body included, to a wall or a seat. The construction being universal makes it possible to manufacture multifunctional optical devices, such as couplers, switches,~~

~~splitters, reflectors, attenuators, combined articles used in optical signal transmission lines, either as a part of optomechanical devices and systems, or independently as a case, fine positioner, or holder of bulk optical devices.~~

~~4. The device ensures high productivity, i.e. high operational characteristics of adjustment, including inter-orientation and locking of the OU carriers, e.g.:~~

~~• high precision of positioning of the bodies, including a wide adjustment range, the latter being possible due to the screw adjustment and the rigid construction links. It is ensured by the simple, manufacturable construction of the device, consisting of only rigid end and interstitial bodies, a spatial hinged and a radial slipping kinematic links, that stabilize the construction and ensure a permanent position of the center or the axis for angular displacement and, respectively, minimum deviation dispersion when positioning the movable body.~~

~~• high reliability, including in the case of pressing sealing requirements, high temperatures, humidity, shocks or vibrations. Such reliability is achieved by using the rigid interstitial body, by the sealing between rigid bodies, as well as by the said kinematic links ensuring mechanical stability of the construction for a longer period of operation;~~

~~• high adjustment productivity due to the shorter time necessary to perform the adjustment operations, due to:~~

~~(a) the smaller number of iterative shifts in the case of combined, i.e. angular and transversal rectilinear adjustment as compared to the separate adjustment, said smaller number determining the permanent position of the angular displacement center/axis, resulting in reduction of the positioning time dispersion, as~~

~~well as the performance of dependent combined adjustments owing to the overall construction;~~

~~(b) the time coincident shifts and locking of the OU carriers, effected by the same coupling and locking screws fitting the kind of adjustment shifts of the bodies;~~

~~(c) the lack of operations loosening the link between the bodies prior to each displacement of the movable body;~~

~~(d) the conventional handling owing to the smaller number of screws, which are combined, i.e. both coupling and locking, instead of being separate, i.e. coupling/adjusting and locking, as well as to their position facilitating the attendance thereof.~~

~~Description of the Figures Enclosed~~

~~Figures 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 represent lengthwise sections of embodiments of the device according to the invention, comprising OA, such as collimators and/or focusing systems, the embodiments being intended for external mounting of the device to a plane, a coupling socket, etc.~~

~~Figure 1 illustrates an OU connector fastened, when mounting the device, along the flange neck of one of its carriers.~~

~~Figure 2 illustrates an OU connector intended for mounting to an apparatus or a panel wall by fastening along a flange face of one of its carriers.~~

~~Figure 3 shows an OU connector, intended for fastening, along two flange faces of the two carriers, to an apparatus or a panel wall.~~

~~Figure 4 shows an OU connector with a flexible hard body, i.e. a spring, sidewise to the interstitial body, the connector being intended for mounting to a wall along a flange face of one of its carriers.~~

~~Figure 5 illustrates an OU connector, intended for sidewise radial mounting through fastening of one of its carriers to the seat of an apparatus or a panel.~~

~~Figure 6 shows a reflecting optical attenuator for sidewise mounting of an end body to an apparatus seat.~~

~~Figure 7 illustrates a series switch with a cylindrical lens for a side assembly of an interstitial body to an apparatus seat or console.~~

~~Figure 8 illustrates a universal variant of a deflector, or a modulator, or an amplifier/attenuator, or a polarizer, depending on the optical properties of the body (substance) partitioning the optical axis, which is intended for mounting the bottom flat of its interstitial body to an apparatus seat or console.~~

~~Figure 9 shows a multi-channel switch of collimated beams with a beamlike optical channel, used for mounting the bottom flat of an end OU carrier, common for all triads of bodies, to a panel or a holder.~~

~~Figure 10 illustrates a rotational reflecting switch for mounting of the immovable part of the interstitial body to a panel or a holder.~~

~~Embodiments of the invention~~

~~**A first embodiment** of the device for connection and adjustment of OA, i.e. elements, modules, devices and systems, according to the invention, is illustrated in Figure 1. Here, the device comprises a triad of two end OU carriers 1, 2 and an interstitial body 3, coupled and locked by means of screws 4, 5, thus forming an optical channel with a homogeneous optical medium, the channel being isolated~~

~~from or communicating with the environment. The three bodies 1, 2, 3 have confronting central through holes shaping the opening of the optical channel. The channel axis is rectilinear. The two end bodies 1, 2 have bearing surfaces for securing of the respective OA, upon the axial adjustment thereof, at a specified distance, the body 1 having a threaded surface 6 and a smooth guiding surface 6' for one of the OA, while the body 2 has only a threaded surface 6 for the other OA. The end body 1 is made of two parts, i.e. a flange with a neck 1' and a hinged member 1". Each of the end bodies 1 or 2 may be fixed, as a housing of the device, to an apparatus seat or a panel by means of its rotational 7 or flat 7' attachment surface.~~

~~The three bodies 1, 2, 3 are hard, the assembled end body 1 being axially connected to the interstitial body 3 by a spatial or a plain hinge, while the end body 2 and the interstitial body 3 are frontally connected in a common slip plane transversal to the axes thereof. Besides, the contact surfaces of the hinge are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contract surfaces 8, 10, 13 of the hinge belongs to the body 1 and has a center 0 on the symmetry axis of the hinged body 3, or has a central axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective concave contact surfaces 8, 10, 13 of the respective hinge are disposed within the volume of the non-connected hinge end body 2. The end body 2 and the interstitial body 3, frontally connected in the slip plane, have each a contact surface 15 transversal to their axes. Each movable body 1 or 2 or 3 of the triad is connected to the next one~~

~~and locked, when effecting OU adjustment, by the same coupling and adjustment screws 4 for rectilinear shifts or 5 for angular shifts of the body. The said screws 4, 5 are arranged in groups, the number of screws being the same or different, and are placed in the end body 2 that is not hinged, the screws 4 of the group for rectilinear shifts of the body being subjected to compression, while the screws 5 of the group for angular shifts of the body are subjected to tension. The screws 4 of the first group are disposed along axes perpendicular to the axes of both the interstitial body 3 and the frontally connected therewith OU carrier 2, while the screws 5 of the other group are disposed along axes parallel to the axes of both the interstitial body 3 and the end body 2 they are placed in. Besides, the axes of the screws 4 and 5 of the two groups are, in pairs, intercrossing and/or perpendicularly intersecting. The device section in Fig. 1 does not contain any indication of the complete number of screws of the two groups 4 and 5, but just a pair thereof. Where the contact surfaces of the hinge are a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14, the axial tightening of all contacting surfaces of the bodies 1, 2, 3 by means of the coupling and locking screws 5, 4 results, at the end of the OU adjustment, in the specified isolation (sealing) of the optical channel. In the other two variants of combinations of the hinged contact surfaces, the optical channel remains in a sidewise communication with the environment, if no sidewise sealing is provided for. According to the embodiment in Fig. 1, all axially connected surfaces of the neighbouring bodies in the hinge and in the front slip plane are tightened together by the screws 5 for angular shifts of the assembled end body 1 and the interstitial body 2 when movable. That link between the bodies 1, 2, 3 renders the rectilinear and~~

~~the angular shifts interdependent. The coupling and locking screws 4, 5 are adjusting as well, i.e. they are used for the overall adjustment of the device by means of a series of stepwise tightening of the screws 4, 5 leading respectively to the angular or transveral rectilinear replacement of the movable bodies 1, 3 or 2, 3, along with the replacement the three bodies 1, 2, 3 being locked to each other with an increasing strength, until achieving the relative position of the axes of the OU carried by the end bodies with the necessary degree of sealing or communication of the optical channel with respect to the environment.~~

~~**A second embodiment** of the device according to the invention is shown in Fig. 2. Here, the device comprises a triad of two end OU carriers 1, 2 and one interstitial body 3, the three bodies being connected and locked by screws 4, 5, thus forming an optical channel, which is isolated from or communicating with the environment. The three bodies 1, 2, 3 have confronting central through holes that shape the opening of the optical channel. The axis of said channel is rectilinear. The end body 1 is flat, while the end body 2 represents a flange with a neck. The flat end body 1 has a smooth attachment surface 6' for securing of the OU and an external face 7'. The body 2 has a threaded surface 6 and a smooth guiding surface 6', both surfaces serving to adjust the axial distance between the two connected OA. The end body 2 is made of a main flange part 2' and a hinged member 2". The device is intended for mounting through an attachment flat face 7' of the flat end body 1 to an apparatus wall or a panel. The body 1 represents a housing of the device. The three bodies 1, 2, 3 are hard, the assembled end body 2 being axially connected through a spatial or a plain hinge to the interstitial body 3, while the end body 1 and the interstitial body 3 are frontally connected in a common slip plane~~

~~transversal to their axes. Besides, the contact surfaces of the hinge are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge belongs to the interstitial body 3 and has a center 0 on the symmetry axis of the body 2 hinged therein, or has a central axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective concave contact surface 8, 10, 13 of the respective hinge are disposed within the volume of the hinged end body 2, while the end body 1 and the interstitial body 3, frontally connected in the slip plane, have a contact plane 15 each that is transversal to their axes. Each movable body 2, 3 of the triad is connected to the neighbouring body and locked, when adjusting the OA, by the same coupling and locking screws 4, 5 fitting the kind of the body shifts. The said screws 4, 5 are arranged in groups, the number of screws being the same or different, and are placed in the end body 1, whereat the screws 4 of the group for transversal rectilinear shifts of the movable body are subjected to compression, while the screws 5 of the group for angular shifts of the body are subjected to tension. The screws 4 of the first group are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end carrier 1 frontally connected therewith, while the screws 5 of the other group are disposed along axes parallel to the axes of both the interstitial body 3 and the end body 1 they are placed in. Besides, the axes of the screws 4, 5 of the two groups are, in pairs, intercrossing and/or perpendicularly intersecting. The embodiment in Fig. 2 does not contain any indication of the full number of screws 4, 5 of the two groups, but just a pair thereof. The coupling and~~

~~locking screws 4, 5 are adjusting at the same time. The results of the axial tightening of all contacting surfaces as shown in Fig. 2, respectively the sealing of the optical channel, as well as those of the overall adjustment of the device by a series of stepwise tightening of said screws 4, 5 coincide with the results as indicated in the embodiment shown in Fig. 1.~~

~~The three bodies 1,2, 3 are axially tightened together by the screws 5 for angular shifts of the movable body 2.~~

~~**A third embodiment**, according to the invention, is shown in Fig. 3. Here, the device comprises a triad of two end OU carriers 1, 2 and one interstitial body 3, connected and locked through screws 4, 5, thus forming an optical channel, the latter being isolated from or communication with the environment. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of the channel is rectilinear. The end body 1 is flat, while the end body 2 is made of two parts assembled through a screw thread, i.e. a flat flange 2' and a hollow neck with a flange 2" passing through the through holes of the flat end body 1 and the interstitial body 3. The flat end body 1 has also a smooth attachment surface 6' of its through hole and an external face 7', respectively for OU securing and for mounting of the device to an apparatus wall or a panel. The end body 2 has a smooth attachment surface 6' for OU securing, as well as a screw link for adjustment of the axial distance between the two OA. The device is intended for mounting to an apparatus wall or a panel by means of the attachment front surface 7' of the immovable end body 1. The body 1 represents a housing of the device. The three bodies 1, 2, 3 are hard, the assembled end body 2 being axially connected to the interstitial body 3 by means of a spatial or plane hinge, while the~~

~~end body 1 and the interstitial body 3 are frontally connected in a common slip plane transverse to their axes. Besides, the hinge contact surfaces are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge belongs to the interstitial body 3 and has a center 0 on the symmetry axis of the end body 2 placed therein, or a central axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective hinge are disposed outside the volume of the three bodies 1, 2, 3, while the end body 1 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transverse to their axes. Each movable body 2, 3 of the triad is connected to the neighbouring body and locked, when effecting OU adjustment, by the same coupling and locking screws 4, 5 fitting the kind of the shifts thereof. The screws 4, 5 are arranged in groups, the number of screws being the same or different, and are placed as follows: the transversal rectilinear shifts group is placed in the end body 1, while the angular shifts group is situated in the end body 2. All screws 4, 5 are subjected to compression. The screws 4 of the first group are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end body 1 frontally connected therewith, while the screws 5 of the second group are disposed along axes parallel only to the axis of the assembled end body 2 they are placed in. Besides, the axes of the screws 4, 5 of the two groups are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 3 contains no indication of the full number of screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting as well. The results of the axial~~

~~tightening of all contacting surfaces as shown in Fig. 3, respectively the sealing of the optical channel, as well as those of the overall adjustment of the device by the number of stepwise tightening of the screws 4 and 5, coincide with the results according to the embodiment in Fig. 1. The three bodies 1, 2, 3 are axially tightened together by the screws 5 for angular shifts of the movable bodies.~~

~~**A fourth embodiment** of the device according to the invention is shown in Fig. 4. Here, the device comprises a triad of two end OU carriers 1, 2 and an interstitial body 3, the three bodies being connected and locked by screws 4, 5, thus forming an optical channel that is isolated from or communicating with the environment. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of said channel is rectilinear. The end body 1 is flat, while the end body 2 is made of two parts, i.e. a flange 2 with a neck 2' and a hinged member 2". The flat end body 1 has a smooth attachment surface 6' for securing the OA, and an external face 7' for mounting the device to an apparatus wall or a panel. The assembled body 2 has a threaded surface 6 and a smooth guiding surface 6' for adjustment of the axial distance between the two OU being connected. The three bodies 1, 2, 3 are hard, the assembled end body 2 being axially connected to the interstitial body 3 by a spatial or plain hinge, while the end body 1 and the interstitial body 3 are frontally connected in a common slip plane transversal to the axes thereof. Besides, the contact surfaces of the hinge are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge, belonging to the assembled end body 2, has~~

~~a center 0 on the symmetry axis of the body 2 hinged therein, or a cental axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective concave contact surfaces 8, 10, 13 of the respective hinge are situated within the volume of the interstitial body 3. The assembled end body 2 and the interstitial body 3, frontally connected in the slip plane, have each a contact surface 15 transveral to their axes. Each movable body 2, 3 of the triad is connected to the neighbouring body and locked, when performing OU adjustment, by means of coupling and locking screws 4, 5 fitting the kind of the shifts. The screws 4, 5 are arranged in groups in the end body 2, the number of screws being the same or different, whereat the screws 4 of the group for transversal rectilinear shifts of the body are subjected to compression, while the screws 5 of the group for angular shifts of the body are subjected to tension. The screws 4 of the first group are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end body 1 frontally connected therewith, while the screws 5 of the second group are situated along axes parallel to the axes of both the interstitial body 3 and the end body 1 they are placed in. Besides, the axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 4 does not contain any indication of the full number of the screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting as well. A part of the screws 4 for transversal rectilinear displacement of the body may be replaced by support spring members 18 that are equivalent to the screws 4 as regards their action. When tightening the angular adjustment screws 5, only the hinge contact surfaces 8 and 9 or 10 and 11/12 or 13 and 14 remain tightened, while the contact~~

~~surfaces 15 of the bodies in the plane of the frontal slipping thereof remain in a permanent force fit within guides 17.~~

~~**A fifth embodiment** of the device, according to the invention, is illustrated in Fig. 5. Here, the device comprises a triad of two end OU carriers 1, 2 and an interstitial body 3, connected and locked by screws 4 and 5, thus forming an optical channel, which is isolated from or communicating with the environment. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of the channel is rectilinear. The end body 1 is cup-shaped and embraces the bodies 2 and 3, while the end body 2 represents a flange with a neck. The embracing end body 1 is made of two parts, i.e. a main part 1' and a flange 1" connected by a thread, ring-likely embracing the cup-shaped back face of the end body 2. The embracing end body 1 has an attachment threaded surface 6 for OU securing and external attachment surfaces 7 and 7' for mounting to an apparatus seat or a panel. The end body 2 has a smooth attachment surface 6' for OU securing. The three bodies 1, 2, 3 are hard, the end body 2 being axially connected to the interstitial body 3 by a spatial or plain hinge, while the end body 1 and the interstitial body 3 are frontally connected in a common slip plane transverse to the axes thereof. Besides, the hinge contact surfaces are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge belongs to the embraced end body 2 and has a center 0 on the symmetry axis of the body 3 hinged therein, or has a central axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective~~

~~concave contact surfaces 8, 10, 13 of the respective hinge are situated within the assembled hinge interstitial body 3, respectively within the volume of the end body 1 embracing it, while the embracing end body 1 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transversal to the axes thereof. Each movable body 2, 3 of the triad is connected to the neighbouring body and locked, when effecting OU adjustment, by the same coupling and locking screws 4, 5 fitting the kind of the body replacement. The screws 4, 5 are arranged in groups in the end body 1, the number of screws being the same or different, whereat all screws 4, 5 of the two groups are subjected to compression. The screws 4 are disposed along axes perpendicular to the axes of both the interstitial body 3 and the embracing end body 1 bearing the screws. The screws 5 are disposed along axes parallel to the axes of both the interstitial body 3 and the end body 2 bearing the screws. Besides, the axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 5 contains no indication as to the full number of screws 4, 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting as well, The results of the axial tightening of all contact surfaces as indicated in Fig. 5, respectively the sealing of the optical channel, as well as those of the overall adjustment of the device by a number of stepwise tightening of the screws 4 and 5, coincide with the results according to the embodiment in Fig. 1. The three bodies 1, 2, 3 are axially tightened together by the screws 5 for angular displacement of the movable bodies.~~

~~**A sixth embodiment** of the device according to the invention is shown in Fig. 6. Here, the device comprises a triad of two end OU carriers 1, 2 and one interstitial body 3, the three bodies being connected and locked by coupling and locking~~

~~screws 4 and 5, thus forming an optical channel, which is isolated from or communicating with the environment. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of the said channel is rectilinear. The end body 1 is dense, either rotational or non-rotational, while the end body 2 represents a flange with a neck. The dense end body 1 has a threaded attachment surface 6 for OU securing and adjustment of the axial distance between the OU connecting bodies, as well as a smooth external attachment surface 7 for mounting to an apparatus seat and a surface 7' for mounting to a table or console. The end body 2 has a smooth attachment surface 6' for OU securing. The three bodies 1, 2, 3 are hard, the end body 2 being axially connected to the interstitial body 3 by a spatial or plain hinge, while the end body 1 and the interstitial body 3 are frontally connected in a common slip plane transversal to the axes thereof. Besides, the hinge contact surfaces are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge belongs to the end body 1 and has a center 0 on the symmetry axis of the interstitial body 3 hinged therein or a central axis 0'–0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective concave contact surfaces 8, 10, 13 of the hinge are disposed within the volume of the interstitial body 3, respectively within the end body 1, while the end body 1 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transversal to the axes thereof. Each movable body 2, 3 of the triad is connected to the neighbouring body and locked, when effecting OU adjustment, by the same coupling~~

~~and locking screws 4, 5 depending on the kind of the body replacement, i.e. screws 4 for transversal rectilinear displacement and screws 5 for angular displacement. The screws 4, 5 are situated in groups in the end body 1, the number of screws being the same or different, whereat the screws 4 are subjected to compression, and the screws 5 are subjected to tension. The screws 4 are disposed along axes parallel to the axes of both the interstitial body 3 and the end body 1 they are placed in. Besides, the axes of the screws 4 and 5, in pairs, are mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 6 does not indicate the full number of the screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting at the same time. The results of the axial tightening of all contact surfaces as indicated in Fig. 6, respectively the sealing of the optical channel, as well as the results of the overall adjustment of the device by a series of stepwise tightening of the said screws 4, 5 are the same as the results according to the embodiment of Fig. 1. The three bodies 1, 2, 3 are tightened together by the screws 5 for angular displacement of the movable bodies.~~

~~**A seventh embodiment** of the device according to the invention is shown in Fig. 7. Here, the device comprises a triad of two end OU carriers 1, 2 and one interstitial body 3, connected and locked by coupling and locking screws 4 and 5, thus forming an optical channel, which is isolated from or communicating with the environment. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of the said channel is rectilinear. The end body 1 represents a flange with a neck, while the end body 2 is an OU seat holder. The end body 1, representing a flange with a neck, has a smooth bearing surface 6' for OU securing, while the end body 2 has a smooth seat 6' for OU~~

~~securing too. The three bodies 1, 2, 3 are hard, the interstitial body 3 representing a housing of the device embracing the whole end body 2. The interstitial body 3 has attachment surfaces 7, 7' for mounting of the device respectively to a socket or a console of an apparatus. The body 3 has also a seat for securing of an additional OU (AOA), the seat being disposed coaxially to but outside the two connected OA. The end body 1, representing a flange with a neck, is axially connected to the interstitial body 3 by a plain hinge, while the end body 2 and the interstitial body 3 are frontally connected in a common slip plane transversal to their axes. Besides, the hinge contact surfaces are a part of a concave cylinder and a base of a parallelepiped 11. The concave contact cylindrical surface 10 belongs to the end body 1 hinged to the interstitial body 3, and has a central axis 0'-0' crossing the symmetry axis of the interstitial body 3 placed therein. The central axis 0'-0' of the hinge is disposed within the volume of the interstitial body 3, while the end body 2 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transversal to the axes thereof. Each movable body 1, 2 of the triad is connected to the neighbouring body and locked, when adjusting the OA, by the same coupling and locking screws 4, 5 fitting the kind of the body/s adjustment shifts. The screws 4, 5 are arranged in groups and placed in the interstitial body 3, the number of screws being the same or different, whereat the screws 4 for transversal rectilinear shifts are subjected to compression, while the screws 5 for angular shifts are subjected to tension. The screws 4 are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end body 2 frontally connected therewith, while the screws 5 are disposed along axes parallel to the axes of both the interstitial body 3 they are placed in and the end body 2. Besides, the~~

~~axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment as per Fig. 7 does not contain any indication of the full number of the screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting as well. The three bodies 1, 2, 3 are, in pairs, axially tightened by coupling and locking screws 4 and 5, that is why the rectilinear or angular adjustment shifts are independent of each other.~~

~~**An eighth embodiment** of the device according to the invention is shown in Fig. 8. Here, the device comprises a triad of two end OU carriers 1, 2 and an interstitial body 3, connected and locked by coupling and locking screws 4 and 5, thus forming an optical channel isolated from or communicating with the environment. The channel has heterogeneous optical medium, determined by the presence of an additional OU placed between the two OU being connected. The three bodies 1, 2, 3 have opposite central through holes shaping the opening of the optical channel. The axis of the said channel is rectilinear. The two end bodies 1, 2 represent flanges with bilaterally projecting necks along the central axes of the bodies 1, 2. The bodies 1, 2 have smooth bearing surfaces 6" for OA. The three bodies 1, 2, 3 are hard, the interstitial body 3 representing a housing of the device with a U-shaped profile. The base of the interstitial body 3 has an attachment surface 7' for the device to be mounted to a panel, seat or console of an apparatus. Besides, it has also a bearing surface 16 for the additional OU (AOA), the latter being disposed between the OU being adjusted and along the axis of the optical channel. The additional OU renders the medium of the optical channel heterogeneous. The end body 1 is externally and axially connected to one of the walls of the interstitial body 3 by a spatial or plain hinge, while the end body 2 is~~

~~externally and frontally connected to the other wall of the interstitial body 3 in a common slip plane transverse to the axes of their through holes. Besides, the hinge contact surfaces are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10 and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave hinge surfaces 8, 10, 13 belongs to the interstitial body 3 and has a center 0 on the symmetry axis of the end body 1 hinged therein, or has a central axis 0'-0' crossing the said axis of symmetry. The center 0 and the central axis 0'-0' of the respective concave contact surfaces 8, 10, 13 of the respective hinge are disposed within the volume of the hinged end body 1, while the end body 2 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane transverse to the axes thereof. Each movable body 1, 2 of the triad is connected to the neighbouring interstitial body 3 and locked, when effecting OU adjustment, by the same coupling and locking screws 4, 5 fitting the kind of the movable body/s adjustment shifts. The screws are arranged in groups and situated in the interstitial body 3, the number thereof being the same or different, whereat the screws 4 for transverse rectilinear adjustment are subjected to compression, while the screws 5 for angular adjustment are subjected to tension. The screws 4 are disposed along axes perpendicular to the axes of both the interstitial body 3 they are placed in and the end body 2 frontally connected therewith, while the screws 5 are disposed along axes parallel to the axis of the interstitial body 3 they are placed in. Besides, the axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 8 does not indicate the full number of the screws 4 and 5, but just a pair thereof. The coupling and locking~~

~~screws 4, 5 are adjusting as well. In addition to the screws 4 and 5, Fig. 8 contains an indication of screws 4' that ensure a fit for the frontal slipping of the end body 2 along the interstitial body 3 in the case of transversal adjustment. The construction according to Fig. 8 makes it possible to effect transverse and angular adjustments, independently of each other by tightening of the respective screws 4, 5 following a number of stepwise shifts of the movable bodies 2 and 1.~~

~~**A ninth embodiment** of the device according to the invention is shown in Fig. 9. Here, the device comprises five triads of two end bodies 1, 2 and one interstitial body 3 each, said bodies being connected and locked by screws 4, 5 forming an optical channel, the latter being isolated from or communicating with the environment. The three bodies 1, 2, 3 of each triad have opposite central through holes forming the opening of the optical channel within the area of those bodies. The end body 2 is common for all the triads of bodies 1, 2, 3, and represents a housing of the device, one of the OU being common too and situated in the center of the housing as a movable reflector or a light source. The optical channel axis is respectively angularly refracted or branched from a common point. The other end body 1 of each triad of bodies 1, 2, 3 represents a flange with a neck and has a smooth bearing surface 6' for the OA. The base of the end body 2, representing a housing, has an attachment surface 7' intended for mounting to a panel or a holder. The three bodies 1, 2, 3 of each triad are hard, the movable body 1 being axially connected to the interstitial body 3 by a spatial or plain hinge, while the end body 2 and the interstitial body 3 are frontally connected in a slip plane transverse to the axes thereof. Besides, the hinge contact surfaces are either a part of a concave sphere 8 and a base of a right circular cylinder 9, or a part of a concave cylinder 10~~

~~and a base of a parallelepiped 11 or a cube 12, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the concave contact surfaces 8, 10, 13 of the hinge belongs to the movable end body 1 and has a center 0 on the symmetry axis of the end body 2 placed therein, or has a central axis 0'-0' crossing the said symmetry axis. The center 0 and the central axis 0'-0' of the respective concave contact surfaces 8, 10, 13 of the hinge are situated within the volume of the interstitial body 3, while the movable end body 1 and the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transverse to the axes thereof. Each movable body 1, 2 of each triad is connected to the neighbouring body and locked, when performing OU adjustment, by the same coupling and locking screws 4 and 5, fitting the kind of the OU adjustment shifts. The screws 4, 5 are arranged in groups of the same or different number of screws and placed in the immovable end body 2, whereat the screws 4 for transverse rectilinear displacement are subjected to compression, while the screws 5 for angular displacement are subjected to tension. The screws 4 are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end body 2 frontally connected therewith, while the screws 5 are disposed along axes parallel to the axes of both the interstitial body 3 and the end body 2 situated therein. Besides, the axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 9 does not contain any indication of the full number of screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting at the same time. The results of the axial tightening of all contact surfaces as shown in Fig. 9, respectively the sealing of the optical channel, as well as those of the overall adjustment of the device by a number of stepwise tightening of said screws 4 and 5,~~

~~are the same as the results according to the embodiment in Fig. 1. The bodies 1, 2 3 of each triad are axially tightened together by the screws 5 for angular displacement of movable bodies.~~

~~**A tenth embodiment** of the device according to the invention is shown in Fig. 10. Here, the device comprises a triad of hard bodies, i.e. two OU carriers 1, 2 and an interstitial body 3 connected and locked by coupling and locking screws 4 and 5, thus forming an optical channel communicating with the environment. The end body 1 and the interstitial body 3 have opposite central through holes forming the opening of the optical channel, whose axis is rectilinear. The end body 1 has a smooth bearing surface 6' for the OA. The end body 2 is dense and is made of two parts assembled by means of threading, i.e. a flange 2' and a table 2" with a smooth bearing surface 6' for the reflecting OA. The table 2" closes one of the openings of the through hole of the interstitial body 3. The body 3 consists of two axially connected parts, i.e. an immovable part 3' and a rotationally movable self-locking part 3", the two parts being hinged with each other. The immovable part 3' represents a housing of the device and has an attachment surface 7 for mounting to a board, a panel, or a holder. Besides, the immovable part 3' has a seat with the end body 1 with the through hole being situated therein, while the movable part 3" has a seat with the table 2" of the end body 2 being placed therein, so that the flange 2' of the end body 2 remains outside the through hole of the movable part 3". The end body 2 is axially connected to the movable part 3" of the interstitial body 3 by means of a spatial hinge, while the end body 1 is frontally connected to the immovable part 3' of the interstitial body 3 in a common slip plane transversal to their axes. Besides, the hinge contact surfaces are either a part of a concave sphere 8~~

~~and a base of a right circular cylinder 9, or a part of a concave ellipsoid 13 and a base of an elliptic cylinder 14. Each of the hinge concave contact surfaces 8 and 13 belongs to the movable part 3" of the interstitial body 3 and has a center 0 on the symmetry axis of the end body 2 hinged therein. The center 0 of the respective concave contact surface 8, 13 of the respective hinge is situated within the volume of the hinged movable part 3" of the interstitial body 3 and the table 2" of the end body 2. The end body 1 and the immovable part 3' of the interstitial body 3, frontally connected in the slip plane, have each a contact plane 15 transverse to the axes thereof. Each movable body 1, 2 of the triad is connected to the neighbouring body and is independently locked, when effecting OU adjustment, by coupling and locking screws 4, 5 fitting the kind of OU displacement. The screws 4, 5 are arranged in groups of the same or different number of screws respectively in the immovable part 3' of the interstitial body 3 and in the flange 2' of the end body 2, whereat the screws 4, 5 of the respective groups for transverse rectilinear and angular OU displacement are subjected to compression only. The screws 4 are disposed along axes perpendicular to the axes of both the interstitial body 3 and the end body 1 frontally connected therewith, while the screws 5 are disposed along axes parallel only to the axis of the end body 2 they are situated in. Besides, the axes of the screws 4, 5 are, in pairs, mutually crossing and/or perpendicularly intersecting. The embodiment in Fig. 10 contains no indication of the full number of the screws 4 and 5, but just a pair thereof. The coupling and locking screws 4, 5 are adjusting as well. The three bodies 1, 2, 3 are, in pairs axially tightened together by the coupling and locking screws 4, 5.~~

~~**Information Sources**~~

~~1. Specifications of the SU Inventor's Certificate No. SU1723550A1~~

~~2. Specifications of SU Inventor's Certificate No. 883838~~

~~3. Specification of Canadian Patent -(A) No. 1258786~~

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a device for adjustably interconnecting optical units.

The device of this invention finds application in optoelectronics, optomechanics, optical communications, instrument engineering, medical engineering, laboratory equipment, and all fields of technology using translation of visual signals between optical units (OU's)

DISCUSSION OF THE PRIOR ART

SU 1723550A1 discloses a device for connection and adjustment of passive optical units, i.e. optical fibers. Optical fibers are arranged in pairs and fixed to carriers, one of which is movable. The two carriers with the optical units are connected in an optical channel isolated from the environment with guaranteed parallelism of the optical axes of the OU's through the channel. The OU carriers are oriented until the two OU's are coaxial. Orientation is carried out by repeated independent, rectilinear, stepwise shifts of the movable carrier in two planes, perpendicular to the axis of the carrier. The movable carrier is tightened and locked to the immovable carrier each shift increasing the locking force. Meanwhile, a running check is carried out with respect to orientation of the carriers and the degree of the optical channel sealing.

A shortcoming of the device is that it allows only parallel and coaxial adjustment of the carriers. Moreover, its operational possibilities and reliability are limited, especially at high temperatures and in harsh environments.

SU 883838 describes a device for OU connection and adjustment, i.e. a reflecting optical element (concave mirror) and an active optical element contained in a sealed optical channel. The reflecting element is fixed to a movable carrier opposite to the optical axis of an immovable carrier, the active optical element being fixed to the latter, while both OU carriers are connected in a sealed optical channel.

The device consists of rigid bodies only, i.e. two OU carriers and a third body which connects the carriers, the three bodies being connected so that they form a sealed optical channel or passage. Auxiliary rigid and resilient mechanical elements connect the bodies, while shifts of the movable carrier are effected by adjusting screws.

A drawback of the device is restricted applicability. The device can be used only for reflecting OU and for spatial and angular OU adjustment, because there is no means of connecting other OU's perpendicular to the optical axis. Another drawback of the device is its low operational reliability because of complicated construction which makes it not resistant to vibration and shock.

CA 1258786 discloses a device for connection and adjustment of fibers. OU's are arranged in pairs and fastened to carriers at a distance from each other. At least one of the carriers is movable. The two carriers with the OU's fastened thereto are connected through a third, intermediate body, so that the three bodies form an optical channel. The bodies forming the optical channel and carrying a pair of OU's are angularly oriented until they are positioned for optimal transmission of visual

signals. The bodies are oriented by means of an iterative series of rectilinear stepwise shifts and locking of a movable OU carrier or carriers (where both carriers are movable). The shifts and locking are accompanied by a running check of the relative position of the optical axes of the OU's. Each angular displacement of a body is preceded by a partial release from locking, and is followed by a new, stronger locking and a check of the relative position of the bodies.

When the optical channel defined by three bodies is to be isolated from the environment, the last operation, i.e. the angular shift and the locking of the movable body, is followed by a final check as to whether the mechanical links between the bodies forming the channel are sealed.

The device includes at least three bodies for each OU pair. The bodies are connected to form an optical channel open to or isolated from the environment or communicating therewith. At least two bodies having central holes define the opening of an optical channel, the axis of which is rectilinear, angular or branched from a common point. Each of the two end bodies has a bearing surface for an OU. One of the bodies, which is fixed, is a housing having an attachment surface for mounting of the device on a panel or apparatus. The two OU's are locked to the bodies at a distance one from each other. The bodies are connected by an intermediate, flexible body and two types of screws. The screws are placed in the fixed carrier. When orienting the OU carrier, the center of angular displacement changes towards the body depending on variable deformation of the intermediate body.

A basic drawback of the device is the fact that it permits restricted spatial orientation of the carriers, only by means of angular shifts of the movable carrier(s).

The device is thus limited to OU connection and adjustment for the purpose of optical beam communication and reflection in small angular ranges. Another drawback of the device are low precision due to restricted angular displacement of the movable body(s). The main drawback of the device is restricted functional possibilities because it is suitable for use with optical and optoelectronic elements only (fibers, reflectors), small angles being enough for the adjustment thereof, due to the limited spatial orientation of its carriers and the restricted possibilities for external mounting. The device is not capable of adjusting the orientation of optical elements having optical axes requiring substantial angular deflections.

An object of the present invention is to provide a solution to the problems inherent in existing apparatuses of the type described above in the form of a relatively simple device for adjustably interconnecting optical units which is easy to adjust, and which lends itself for use with a wide variety of optical units.

GENERAL DESCRIPTION OF THE INVENTION

Accordingly, the present invention relates to a device for interconnecting optical units comprising a first carrier, a second carrier, an intermediate body between said first and second carriers, said first and second carriers and said intermediate body having central axes, at least two of said carriers and said intermediate body being adopted to support an optical unit; passages in at least two of said first and second carriers and said intermediate body defining an optical path, a hinge rotatably connecting one of said first and second carriers to the other of said first and second carriers and said intermediate body; first screw means for causing rotation of said one carrier relative to said other carrier and said intermediate body to change the shape and length of said optical path; and second screw means for

causing at least one of said first and second carriers and said intermediate body to move transversely of the optical path to change the alignment of said central axes and the shape of the optical path.

The three elements listed above, i.e., the two carriers and the intermediate body are rigid, and are actually connected by a hinge. One carrier or the intermediate body is slidable with respect to the other carrier for movement transversely thereof. The contact surfaces of the hinge are either part of a sphere and a right circular cylinder, part of a cylinder and a parallelepiped or a cube, or part of a concave ellipse and an elliptical cylinder. The spacial relationship between the carriers and the intermediate body is adjusted by means of a plurality of screws arranged in pairs. Orientation of the three elements is effected by stepwise movement of the elements relative to each other. Because of the reaction forces between the screws and the elements, the screws also serve to lock the elements in one position. Some of the coupling and adjustment screws can be replaced by springs. The screws or springs are arranged in groups according to their function, i.e. for effecting rectilinear or angular adjustment of one or more of the elements of the device. The axes of the first screws intersect and are perpendicular to the axes of the second screws when the elements are centered and aligned.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described below in greater detail with reference to the accompanying drawings which illustrate preferred embodiments of the invention, and wherein:

Figures 1 to 10 are schematic, sectional views of various embodiments of the device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Fig. 1, a first embodiment of the device of the present invention includes three elements, namely two carriers 1 and 2 for optical units 3 and 4, and an intermediate body 5. The elements 1, 2 and 5 are interconnected by screws 6 and 7. The three elements have central passages 9, 10 and 11 with central, longitudinal axes 0, 0' and 0", respectively which define an optical channel or path in the device. The optical path , which is rectilinear, is isolated from or communicates with the environment.

The carrier 1 has a tubular body 12, with a flange 13 on one end thereof. The interior of the body 12 has a smooth outer end and threads 15 at the inner end thereof for mounting the optical unit 3. The outer surface of the body 18 and the flange 19 are smooth for mounting the device on an apparatus or panel (not shown). The carrier 2 also has a tubular body 18 with a flange 19 at one end opposing the flange 13 of the carrier 1. The carriers 1 and 2 are interconnected by a plurality of spaced apart screws 6 (one shown) extending through a washer 20 and a large hole 21 in the flange 13 of the carrier 1 into a threaded bore 22 in the flange 19 of the carrier 2. The large hole 21 permits tilting of the carrier 2 with respect to the carrier 1.

The intermediate body 3 is slidably mounted in a recess 24 in the flange 17 for movement transversely of the longitudinal axes of the carriers 1 and 2. The location of the body 5 in the recess 24 is controlled by the screws 7. The screws 6 and 7 are arranged in groups with their longitudinal axes intersecting.

The carrier 2 and the intermediate body 5 are tilted with respect to the carrier 1 by a hinge defined by an insert 25 in the flange 13 and the free end 27 of the body

5. The insert 25 has a concave recess 28 for rotatably receiving the free end of the body 5, and a central hole or passage 29 aligned with the passage 9 through the body 12 of the carrier 1.

The contact surfaces of the hinge, i.e. the recess 28 and the free end of the intermediate body 5 are part of a sphere and one end of a right circular cylinder, respectively. Alternatively, the contact surfaces are cylindrically concave and one end of a parallelepiped or a cube, or part of an ellipse and one end of an elliptical cylinder.

In effect, the concave contact surface of the hinge, i.e. the recess 28 is part of the carrier 1 with the longitudinal axis or axis of symmetry 0 on the longitudinal axis 0" of the intermediate body 5, when the two are aligned, or has a longitudinal axis 0 intersecting the axis of symmetry 0" of the body 5 when the carrier 2 and the body 5 are tilted or inclined with respect to the carrier 1. It will also be appreciated that the longitudinal axis 0" of the intermediate body 5 can be shifted transversely with respect to the longitudinal axes 0 and 0' of the carriers 1 and 2 so that the axes 0, 0' and 0" of the three elements are not aligned, i.e. are inclined with respect to each other. Thus, the shape, length and direction of the optical passage through the device can be altered by adjusting the screws 6 and 7. By changing the angles between the axes 0, 0' and 0", the shape of the optical passage through the three elements of the device is changed. The angle and possibly the length of the optical passage are changed by means of the adjustment screws 6. When the alignment of the axes 0, 0' and 0" is changed by adjusting the screws 7, the shape and direction of the optical passage changes.

With reference to Fig. 2, a second embodiment of the invention includes first and second carriers 31 and 32, respectively and an intermediate body 33 which are adjustably interconnected by screws 6 and 7. Passages 35, 36 and 37 in the two carriers 31, 32 and the intermediate body 33, respectively define an optical passage, which is isolated from or communicates with the atmosphere. The carrier 31 includes a flat body 39 containing a recess 40 for slidably receiving the intermediate body 33. The carrier 32 is cylindrical with an annular flange 42 intermediate the ends thereof for receiving the screws 6, which extend through large washers 43 and holes 44 into threaded holes 45 (one of each shown) in the carrier 31 to interconnect the carriers 31 and 32. One end of the carrier 32 is rotatable in a concave recess 46 in the body 33.

The intermediate body 33 is moved transversely of the carrier 31 by means of the screws 7.

The passages 35 and 36 through the carriers 31 and 32, and the passage 37 through the intermediate the body 33 have longitudinal axes 0, 0' and 0", respectively. The axes 0' and 0" are moved laterally with respect to the axis 0 when the body 33 is slid transversely in the recess 40. The axes 0, 0' and 0" can be aligned or (as illustrated schematically in Fig. 2), inclined with respect to each other by adjustment of the screws 6. As in the device of Fig. 1, the screws 6 and 7 are arranged in groups, and adjustment of the length, direction and shape of the optical passage through the device is effected in the same manner as with the first embodiment of the device.

Referring to Fig. 3, a third embodiment of the invention includes a first carrier 48, a second carrier 49 pivotally connected to the carrier 48 and an intermediate

body 50. The first carrier 48 is defined by a block with a flat surface 52 for connecting the carrier to an apparatus or panel (not shown). The intermediate body 50 is slidably mounted in a recess 53, which defines part of a central passage 54 in the carrier 48, for lateral or transverse movement by adjustment screws 7. The carrier 49 includes a plate 55 and a cylindrical tube 56 mounted therein. The carrier 49 is pivotally connected to the intermediate body 50 and the carrier 48 by a flange 57 on the free end of the tube 56 which is rotatable in a concave recess 58 in the intermediate body 50. The carriers 48 and 49 and the body 50 have central passages 54, 61 and 62, respectively with longitudinal or central axes 0, 0' and 0", respectively. The simultaneous alignment of the axes and self locking of the three elements can be changed using the screws 6 and 7. Thus, longitudinal and transverse adjustments of the carriers 48 and 49 and tilting of the axes of the elements of the device are effected using screws 6 and 7 in essentially the same manner as in the first two embodiments of the device.

A fourth embodiment of the invention (Fig. 4) includes first and second carriers 64 and 65, respectively and an intermediate body 66 slidably mounted in a recess 68 in the first carrier 64. The first carrier 64 is similar to the carrier 48 of the third embodiment of the invention, except that the recess 68 faces the second carrier 65. The second carrier 65 is similar to the carrier 2 of the first embodiment of the invention, including a tubular body 70 and a flange 71 on one end thereof. A recess 72 in the flange 71 contains a hinge member defined by an insert 73, which has a concave bearing surface 74 for pivotally supporting a sleeve 75 extending outwardly from the intermediate body 66.

Passages 76, 77 and 78 in the carriers 64 and 65, and in the intermediate body 66, respectively have longitudinal axes 0, 0' and 0". The spacing between the carriers 64 and 65, the angle between the axes 0, 0' and 0" and the alignment thereof can be altered by rotation of the screws 6 and 7. The intermediate body 66 is biased towards the screws 7 by springs 80 (one shown) mounted in opposed recesses in the carrier 64 and the intermediate body 66. A screw 81 extending through a slot 82 in the body 66 into the carrier 64 guides the body 66 in the carrier body recess 68.

Referring to Fig. 5, in the fifth embodiment of the invention, optical units 84 and 85 are mounted in first and second carriers 87 and 88, respectively which are pivotally interconnected by a tubular intermediate body 90. The first carrier 87 includes a housing 91 having an outer surface 92 for mounting the carrier on an apparatus or panel. One end of the intermediate body 90 is slidable in a recess 93 in one end 94 of the housing 91. The body 90 can be moved laterally in the first carrier 87 by screws 7 (one shown). The other end of the body 90 extends into a concave recess 97 in the second carrier 88. The second carrier 88 is rotated relative to the first carrier 87 and the intermediate body 90 by screws 6 (one shown). The carrier 87 includes a tubular body 98 with a flange 99 on one end thereof containing the recess 97. The screws 6 engage the flange 99 at spaced apart locations.

As shown in Fig. 6, a sixth embodiment of the invention includes first and second carriers 101 and 102, respectively interconnected by screws 6, and an intermediate body 103 slidably mounted for transverse movement in a recess 105 in the first carrier 101. The body 103 is moved transversely in the recess 105 by

screws 7. Adjustment of the device, i.e. altering of the optical passage through the device of Fig. 6 is the same as in the other embodiments of the invention described above. Like the carriers of other embodiments, the carrier 101 has a smooth outer surface 107 for mounting the device on an apparatus or panel.

The embodiment of the invention shown in Fig. 7 includes first and second carriers 111 and 112 for optical units 113 and 114, respectively and an intermediate body 115. The carrier 111 is structurally similar to the carrier 1 of Fig. 1 including a tubular body 117 and a flange 118 at one end thereof through which pass the screws 6. The first carrier 111 contains a concave recess 119 for rotatably supporting one end of the intermediate body 115. By adjusting the screws 6, the body 115 and the second carrier 112 are rotated relative to the first carrier 111. The carrier 112 includes a concave recess for housing the optical unit 114. The carrier 112 is slidably mounted in a compartment 120 in the intermediate body 115. Screws 7 are used to adjust the lateral or transverse position of the carrier 112 in the compartment 120. A flange 121 at one end of the body 115 receives the screws 6 and 7 for tilt/lateral adjustment of the position of the second carrier 117 in the intermediate body. A second end wall 122 of the body 115 contains a seat for a third optical unit 124.

With reference to Fig. 8, an eighth embodiment of the invention includes first and second pairs of carriers 126 and 127 for optical units 128 and 129, respectively, and a generally U-shaped intermediate body 130 carrying a third optical unit 132. The carrier 126 is similar to the carrier 32 of Fig. 2, including a tubular body 133 and a flange 134 intermediate the ends thereof. Screws 6 extend through washers 136 and large holes 37 in the flange 134 into threaded bores 139 in one end wall 140 of

the intermediate body 130. One end 141 of the carrier 126 is pivotally mounted in a concave socket or recess 142 in the end wall 140. Adjustment of the angle of the carrier body 133 with respect to the intermediate body 130 is effected using the screws 6.

The second carrier 127 is slidably mounted in a second end wall 144 opposed to the end wall 140 of the generally U-shaped intermediate body 130 perpendicular to the optical path. The carrier 127 is similar to the carrier 126, including a tubular body 146 and a flange 147 intermediate the ends of the body. One end of the body 146 is slidably mounted for transverse movement in a recess 148 in the end wall 144 of the intermediate body 130. The position of the carrier 127 in the recess 148 is controlled by screws 7. The carrier 127 is positioned in the recess 148 by a screw 149 extending through a slot 150 in the flange 147 into a threaded bore 152 in the intermediate body 130. The third optical unit 132 is mounted on the base 154 of the body 130.

The device of Fig. 9 includes a plurality of first carriers 156, a second carrier 157 and a plurality of intermediate bodies 158 pivotally connecting the carrier 156 to the carrier 157. Optical units 160 and 161 are mounted in the carriers 156 and 157, respectively. Each first carrier 156 includes a tubular body 162 with a flange 163 on one end thereof The second carrier 157 is in the form of a polygonal housing with an intermediate body 158 in each wall thereof. Each first carrier 156 is connected to the second carrier 157 by screws 165 (one represented schematically by an arrow) extending through the flange 163. Each first carrier 156 includes a concave recess 166 for receiving an outer end of an intermediate body 158.

Each intermediate body 158 is slidably mounted in a recess 167 in a side wall 168 of the polygonal second carrier 157. The intermediate bodies 158 are moved transversely of the longitudinal axes of passages170 in the side walls 168 of the polygonal second carrier 157, i.e. perpendicular to the optical paths through the carriers and the intermediate bodies 158 by screws 171 (two represented schematically by crosses).

With reference to Fig. 10, a tenth embodiment of the invention includes first and second carriers 175 and 176 mounted in opposite ends of an intermediate body 177. The body 177 is in the form of a two-piece, tubular housing, one piece 178 of which contains the first carrier 175, and the other piece 179 of which contains the second carrier 176. The first carrier 175 is slidably mounted on a partition 180, and the carrier 176 is rotatably mounted on a partition 181. The two pieces of the intermediate body 177 are rotatably interconnected by bearings 183. As in other embodiments of the invention, the body 177 has outer surfaces 182 for attachment of the device to an apparatus or panel.

Optical units 184 and 185 are mounted in the tubular first carrier 175, and an optical unit 186 is mounted on an inner end of the second carrier 176. The first carrier 175 is moved laterally in the intermediate body 177 by adjusting screws 7 (one shown) which extend through a side wall 186 of the body 177 into engagement with the carrier 175.

The second carrier 176 includes a plate 188 on one end of a body 189, which extends through an opening 190 in the second piece 179 of the intermediate body 177 into a compartment defined by opposed recesses in the two pieces of the

intermediate body 177. A flange 192 on the inner end of the body 189 is pivotally mounted in a concave recess 193 in the partition 181.